MONDAY, NOVEMBER 17, 2025 AP CHEMISTRY

CH. 6 ELECTRONIC STRUCTURE OF ATOMS

INTRO DEMOS

① COLOR MIXING WITH FILTERS, LENSES, AND OVERHEAD
② COLOR PERCEPTION W/ CALENDULA FLOWER & SULFUR BUTTERFLY (JPG & XLSX – IN LECTURES FOLDER OF SCI SITE)
③ THE PHYSICAL REALITY OF WAVELENGTH WITH RED, GREEN, AND BLUE LASERS AND A DIFFRACTION GRATING.

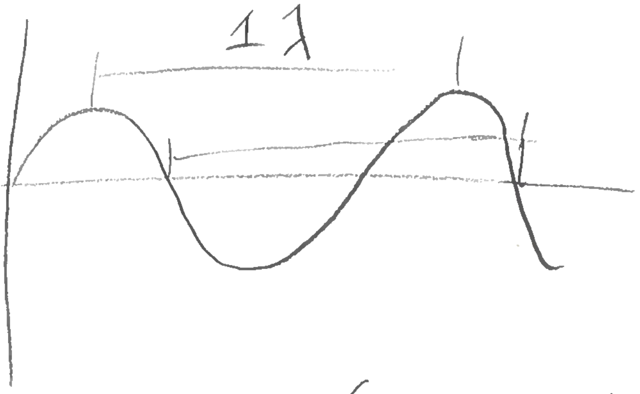
6.1 ELECTROMAGNETIC RADIATION

LIGHT OR E-M RADIATION CAN BE MODELED AS EITHER:

1. WAVES OF ELECTROMAGNETIC FORCE AND NOT A MATERIAL OBJECT
2. PARTICLES OF PURE ENERGY WITH NO MASS BUT YES MOMENTUM (PHOTONS)

WE HAVE TO USE BOTH MODELS EVEN THOUGH THEY CONTRADICT EACH OTHER.

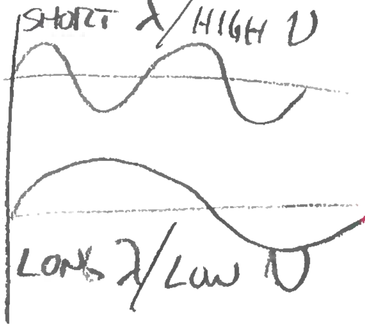
LIGHT AS A WAVE



WAVELENGTH: LENGTH BTWN. TWO IDENTICAL POINTS ON A WAVE

SYMBOL: λ "LAMBDA" (UPPERCASE Λ)

UNITS: METERS (m) mm μm nm



FREQUENCY: NO. OF WAVES PER SECOND

SYMBOL: ν "NU" (UPPERCASE N)

UNITS: PER SECOND $(\frac{1}{s})$ HERTZ ($1\,Hz = 1/s$)
s^{-1} kHz MHz GHz

MUSIC: bpm ①
$1/min = min^{-1}$

$\lambda \cdot \nu$ = SPEED B/C $(m)(\frac{1}{s}) = m/s$

LIGHT IN A VACUUM TRAVELS AT $C = 3.00 \times 10^8 \frac{m}{s}$

SO REMEMBER THIS $\boxed{C = \lambda \nu}$

BE FAMILIAR WITH VARIOUS RANGES WITHIN THE E-M SPECTRUM. (SEE YOUR REF. DOC. AND COLORING PAGE)

400nm 700nm

GAMMA RAYS (γ-RAYS)	X-RAYS	UV	VISIBLE	IR	MICROWAVE	RADIO
	1s-10s nm	100s nm	VIBGYOR	μm	mm	m.

UPPERCASE "GAMMA" Γ

INCR. λ →

DECR ν →

DECR. E PER PHOTON →

6.2 QUANTIZED ENERGY

QUANTIZED JUST MEANS STEP-WISE OR NON-CONTINUOUS.

STAIRS = QUANTIZED PE VALUES
RAMPS = CONTINUOUS PE VALUES

WHY DID WE ADOPT A MODEL OF QUANTIZED ENERGY FOR LIGHT?

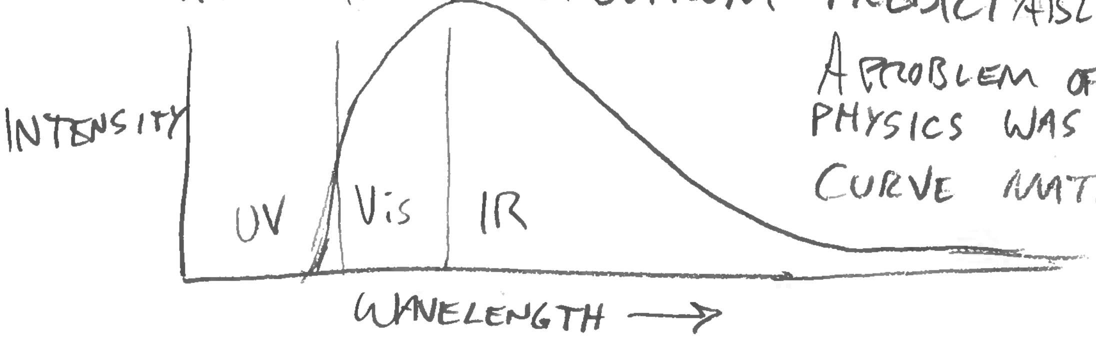
IN ORDER TO ACCOUNT FOR ① BLACKBODY RADIATION
② PHOTOELECTRIC EFFECT

M2025-11-17 AP CHEM

BLACKBODY RADIATION

ALL OBJECTS WITH A TEMPERATURE GIVE OFF E-M RADIATION.

A BLACK OBJECT, IN A TECHNICAL SENSE, IS A PERFECT THERMAL RADIATOR AND WILL PRODUCE E-M RADIATION IN A SPECTRUM PREDICTABLE BASED ON ITS TEMP.



A PROBLEM OF LATE-1800s PHYSICS WAS MODELING THIS CURVE MATHEMATICALLY.

THE PROBLEM WITH THE MODELS WAS THAT THEY PREDICTED EVER MORE ENERGY AT SHORTER AND SHORTER WAVELENGTHS: THE "UV CATASTOPHE".

TO FIX THIS MATH-TASTROPHE MAX PLANCK INTRODUCED THE IDEA OF QUANTIZED ENERGY INTO THE EQUATIONS. FOR HIM, IT WAS JUST MATH, NOT A CONCEPTUAL DESCRIPTION.

AS IT HAPPENED, TAKING THE IDEA SERIOUSLY MEANT USING A PARTICLE-MODEL FOR LIGHT — WE HAVE CREATED THE IDEA OF PHOTONS.

WE USE E AS A VARIABLE TO REPRESENT THE ENERGY OF A SINGLE QUANTUM OR PHOTON (NOT PER MOLE).

$E = h\nu$ E DEPENDS ON FREQUENCY IN A DIRECT PROP. (HIGHER ν MEANS HIGHER ENERGY)

h = PLANCK'S CONSTANT 6.626×10^{-34} J·s

STOPPED HERE GROUP X M2025-11-17

SEE ALSO PhET BLACKBODY RADIATION

PHOTOELECTRIC EFFECT

$c = \lambda \nu$
$E = h\nu$ so $\boxed{E = h\frac{c}{\lambda}}$ B/C $\nu = \frac{c}{\lambda}$

THIS IS THE PRODUCTION OF FREE ELECTRONS DUE TO THE INCIDENCE OF LIGHT ON A SURFACE. THIS IS THE PRINCIPLE UNDERLYING DIGITAL IMAGING AND SOLAR POWER.

ELECTRONS ARE ONLY EJECTED WHEN LIGHT WITH SOME MAXIMUM WAVELENGTH (SO, MINIMUM ENERGY) SHINES ON THE SURFACE. WAVELENGTHS LONGER THAN THAT DO NOT CAUSE e^-s TO BE EJECTED.

STOPPED HERE GROUP X W 2025-11-19 →

IT WAS DETERMINED THAT THIS RESTRICTION WAS DUE TO THE QUANTUM NATURE OF ENERGY IN LIGHT AND ATOMS. IN ORDER TO SEPARATE AN ELECTRON FROM AN ATOM A PHOTON MUST HAVE AT LEAST A MINIMUM ENERGY (E). ANY ENERGY IN EXCESS OF THE MINIMUM IS CONVERTED INTO THE KINETIC ENERGY (KE) OF THE EJECTED ELECTRON.

$$E_{PHOTON} = \underbrace{E_{EJECT.}}_{\text{(MINIMUM EJECTION ENERGY)}} + E_{KE}$$

E_{KE} — HIGHER KE MEANS A FASTER e^-

ALBERT EINSTEIN PUBLISHED A PAPER ABOUT THE PHOTOELECTRIC EFFECT IN 1905, KICKING OFF THE QUANTUM REVOLUTION IN PHYSICS.

STOPPED HERE GROUP Y →
W2025-11-19

$\boxed{\text{DEMO: ENERGY IN PHOTONS}}$

FLUORESCENCE IS FUN!

④

F 2025-11-21 AP CHEM

6.3 LINE SPECTRA AND THE BOHR MODEL

TYPES OF SPECTRA

(DEMO WITH A DIFFRACTION GRATING AND WHITE LIGHT SOURCE)

① CONTINUOUS SPECTRUM – ALL THE COLORS OF THE RAINBOW WITHOUT ANY GAPS AS PRODUCED BY A HOT OBJECT IN BLACKBODY RADIATION

② ABSORPTION SPECTRUM – A CONTINUOUS SPECTRUM INTERRUPTED BY DARK LINES AT SPECIFIC WAVELENGTHS, WHICH ARE MISSING LIGHT ABSORBED BY GAS BTWN THE LIGHT AND YOU.

③ EMISSION SPECTRUM – LINES OF BRIGHT LIGHT AT SPECIFIC WAVELENGTHS AS A GAS THAT IS ENERGIZED BY ELECTRICITY OR VERY HIGH TEMP. (VERY LOW PRESSURE)

(TAKE A LOOK AT THE SPECTRUM ANALYSIS POSTER)

EACH ELEMENT HAS A UNIQUE EMISSION SPECTRUM WITH LINES AT SPECIFIC WAVELENGTHS. THIS CAN BE USED TO IDENTIFY AND EVEN DISCOVER ELEMENTS.

IN AN ABSORPTION SPECTRUM, ELEMENTS CAUSE DARK LINES AT THE SAME λS AS IN THEIR EMISSION SPECTRUM.

He HELIUM (HELIOS) DISCOVERED IN THE SUN
Rb RUBIDIUM – RUBY COLOR IN A SPECTRUM
Cs CESIUM – BLUE SKY COLOR
~~CÆSIUM~~
Tl THALLIUM – A NEW GREEN SHOOT

SPECTROSCOPICALLY DISCOVERED ELEMENTS

THE EMISSION SPECTRUM IS UNDERSTOOD TO REVEAL THE INNER WORKINGS OF ELECTRONS IN ATOMS.

Our Model

★ Electrons orbit the nucleus at specific distances called energy levels, which are quantized.

★ The nucleus is at the bottom of a potential energy well. As electrons get closer, they have lower PE.

★ Outside of an atom, too far away to feel the attraction of opposite charge, the e^- has **zero** PE.

★ At closer energy levels, e^-s in an atom have lower PE, so starting at zero their PE is a negative number.

★ Electrons can transition btwn. energy levels.

Absorption (abs. spectra)

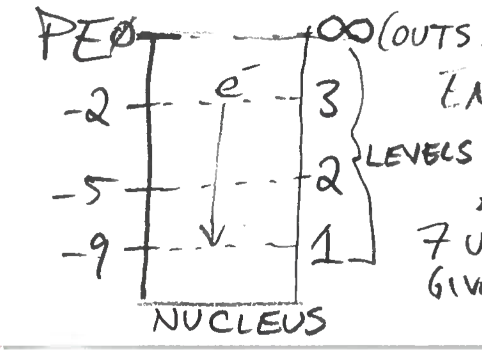
- If an e^- is to move from a lower level (E_i) to a higher level (E_f) so $E_f > E_i$ and ΔE is +, then it must absorb a photon with an energy equal to ΔE.

Emission (emiss. spectra)

- If an e^- moves to a lower level then it gives off a photon with an energy equal to ΔE ($E_f < E_i$) (ΔE is −).

Pause here, group X F 2025-11-21 to do Atomic Emission Lab.
Group Y also, same day

Visual Model of Photon Emission/Absorption



Emission Example

$L_3 \rightarrow L_1$

$\Delta E = -9-(-2) = -7$

7 units of energy given off as a photon

Absorption Example

$L_2 \rightarrow L_3$

$\Delta E = -2-(-5) = +3$

3 units of energy must be abs. from a single photon

F 2025-11-21 APCHEM

ANOTHER THING THAT CAN HAPPEN IS THAT ELECTRONS CAN ABSORB SO MUCH ENERGY THAT THEY SEPARATE FROM THE ATOM. THIS IS CALLED <u>IONIZATION</u>. THE ENERGY REQUIRED TO DO THIS IS, AT MINIMUM, EQUAL TO THE PE OF AN e^- IN THE ATOM THAT WILL BE IONIZED.

THE BOHR MODEL

(SEE ABOVE)

ENERGY LEVELS ARE LABELLED WITH INTEGERS, STARTING WITH ONE (1, 2, 3, 4, ...) FROM LOW PE TO HIGH PE. THESE NUMBERS WE WILL UNDERSTAND AS THE PRINCIPAL QUANTUM NUMBERS.

① ELECTRONS ARE CONFINED TO SPECIFIC ORBITS WITH QUANTIZED PE.

② DESPITE THE FACT THAT OPPOSITE ELECTRIC CHARGES ATTRACT, ELECTRONS DO NOT SIMPLY FALL DOWN AND REST ON THE NUCLEUS.

③ ELECTRONS TRANSITION BTWN. ORBITS BY EMITTING OR ABSORBING PHOTONS WITH ENERGIES EQUAL TO ΔE BTWN. ORBITS.

← STOPPED HERE GROUP Y / F2025-11-21

6.4 WAVE BEHAVIOR OF MATTER

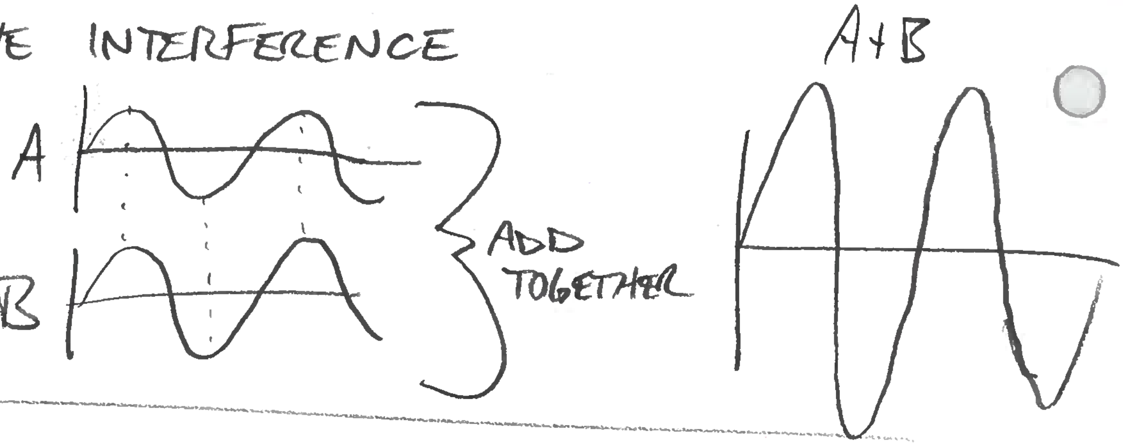
WE CANNOT PRECISELY DESCRIBE THE LOCATION, SPEED, AND ENERGY, OR DURATION OF PARTICLES AND EVENTS AT ALL TIMES. INSTEAD WE USE THE MATH OF PROBABILITY TO DESCRIBE THE BEHAVIOR OF QUANTUM PARTICLES. WE ARE CALC. THE PROB. OF INTERACTIONS WITH INCREDIBLE PRECISION.

TO CALC. THE PROBABILITES WE MODEL ELECTRONS AND PHOTONS USING WAVE EQUATIONS.

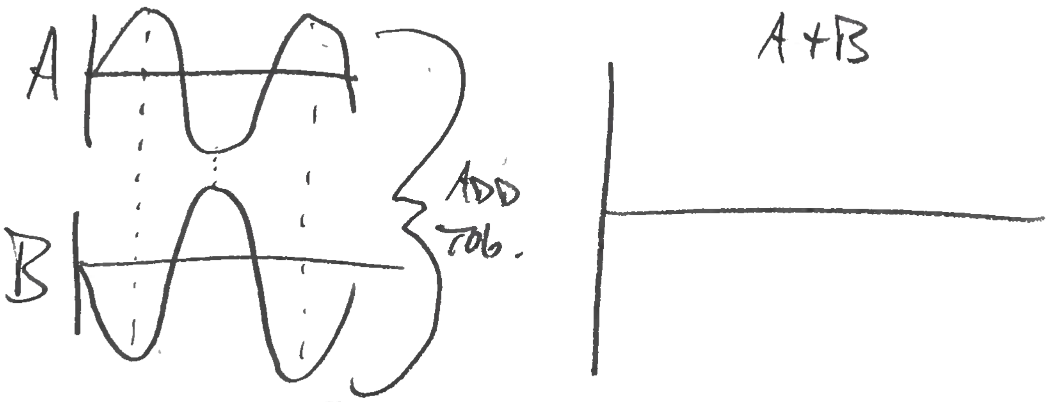
DON'T WORRY, NO $\sin x$ OR $\cos x$ FOR US.

ASIDE: WAVE INTERFERENCE

CONSTRUCTIVE



DESTRUCTIVE



STOPPED HERE F 2025-11-21 GROUP X

IF WE MODEL ELECTRONS AS WAVES THEN THIS GIVES US AN OPPORTUNITY TO EXPLAIN WHY THEY ORBIT AN ATOMIC NUCLEUS ONLY AT SPECIFIC DISTANCES. ELECTRONS ONLY ORBIT WHERE THEIR WAVE-DESCRIPTIONS CONSTRUCTIVELY INTERFERE. ELECTRONS CANNOT BE FOUND WHERE THEY DESTRUCTIVELY INTERFERE.

THE DE BROGLIE (DE BROY) (NOT DE BROCCOLI) WAVELENGTH IS THE WAVE-DESCRIPTION WAVELENGTH OF A "PARTICLE".

$$\lambda = \frac{h}{mV}$$

$h = 6.626 \times 10^{-34}$ J·s

m = MASS IN kg

V = VELOCITY IN m/s

λ COMES OUT IN METERS — TRUST ME OR DO THE DIM. ANALYSIS YOURSELF.

Tu 2025-11-25 AP CHEM

FOR EX. AN e^- ($m = 9.11\times10^{-31}\,kg$) MOVING AT $v = 6\times10^{6}\,m/s$

$$\lambda = \frac{6.626\times10^{-34}\,J\cdot s}{(9.11\times10^{-31}\,kg)(6\times10^{6}\,m/s)} = \boxed{1.2\times10^{-10}\,m}$$

1.2 Å
120pm

THIS IS COMPARABLE TO AN ATOM'S RADIUS

WHAT ABOUT A BASEBALL?

$m = 0.145\,kg$

$v = 45\,m/s$

$\lambda = 1.0\times10^{-34}\,m$ (10^{19} TIMES SMALLER THAN AN ATOMIC NUCLEUS)

WE NEVER OBSERVE WAVE INTERFERENCE WITH BASEBALLS!

THE HEISENBERG UNCERTAINTY PRINCIPLE (H.U.P.)

MEASUREMENTS ARE ALWAYS SUBJECT TO UNCERTAINTY.

IN CLASSICAL PHYSICS THERE IS NO THEORETICAL LIMIT TO THE AMOUNT YOU CAN REDUCE THE UNCERTAINTY, ONLY A PRACTICAL ONE.

IN QUANTUM PHYSICS THERE IS A THEORETICAL LIMIT TO HOW MUCH YOU CAN REDUCE UNCERTAINTY. IT'S LIMITED IN THIS WAY: WHEN YOU REDUCE UNCERTAINTY IN MEASUREMENT FOR THE LOCATION OF A PARTICLE THERE IS AN UNAVOIDABLE AND PROPORTIONAL INCR. IN UNCERTAINTY IN MEAS. OF VELOCITY.

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

THE MORE PRECISELY YOU MEASURE POSITION THE LESS PRECISE IS YOUR KNOWLEDGE OF VELOCITY.

p IS MOMENTUM, $p = m\cdot \overset{\downarrow}{v}$

IMPLICATIONS OF THE H.U.P.

~~quequbit~~
qubit!
~~qbit~~

① ELECTRONS CANNOT BE MODELED LIKE A PLANET ORBITING A SUN. A PLANET HAS A PRECISELY DEFINED POSITION AND MOMENTUM AT EVERY MOMENT.

② IT'S ONLY POSSIBLE TO CAL. <u>PROBABILITIES</u> FOR INTERACTIONS B/TWN QUANTUM PARTICLES AND WE CANNOT SAY WHAT PARTICLES ARE DOING WHEN NOT INTERACTING.

↑

BECAUSE OF NO. 2 WE MODEL e^-S IN ATOMS USING CLOUDS OF PROBABILITY (VOLUMES OF SPACE WHERE AN e^- MAY BE FOUND, IF MEASURED).

ε Υ
ε υ
EPS.. UPS...

6.5 QUANTUM MECHANICS

Ψ (GREEK CAPITAL PSI) STANDS FOR A PARTIAL DIFFERENTIAL EQUATION IN 3 DIMENSIONS PLUS TIME. (WE WILL NOT DO THIS MATH). IT IS CALLED THE WAVE FUNCTION OR SCHRÖDINGER'S WAVE EQUATION.

THE VALUE OF Ψ^2 GIVES THE PROBABILITY DENSITY FOR AN e^- IN AN ATOM.

Ψ^2 IS USED TO CALC. THE SHAPES OF ELECTRON ORBITALS

AN ORBITAL IS A 3D VOLUME IN WHICH AN e^- IS LIKELY TO BE FOUND.

THE SOLUTIONS FOR Ψ INCL. 4 QUANTUM NUMBERS WHICH WE WILL USE TO ORGANIZE OUR DESCRIPTION OF HOW ELECTRONS ARE DISTRIBUTED IN ORBITALS IN A GIVEN ATOM.

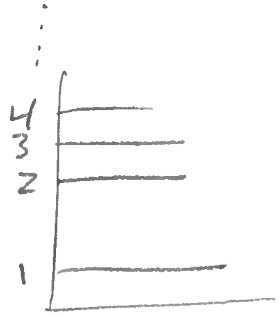
TU 2025-11-25 AP CHEM

FOUR QUANTUM NUMBERS

EVERY e^- IN AN ATOM HAS A UNIQUE SET OF 4 QUANTUM NUMBER VALUES.

n PRINCIPAL QUANTUM NUMBER

LOWERCASE enn



POSSIBLE VALUES $n = 1, 2, 3, \ldots$

REFERRED TO AS

- ENERGY LEVEL
- SHELL NUMBER

GIVES THE PE OF AN e^- IN A GENERAL WAY.

AS PE INCR., SO DOES THE SIZE OF A SHELL AND DISTANCE FROM THE NUCLEUS.

SHELLS HAVE SUB-SHELLS, THE NUMBER OF POSSIBLE SUB-SHELLS DEPENDS ON n.

l ANGULAR MOMENTUM QUANTUM NUMBER

POSSIBLE VALUES $l = 0, 1, 2, \ldots, n-1$

REFERRED TO AS

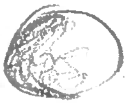
- SUB-SHELL NUMBER

IT CONTRIBUTES TO PE VALUE.

$n=1$ $l=0$
$n=2$ $l=0$, or 1
$n=3$ $l=0, 1$, or 2
$n=4$ $l=0, 1, 2$, or 3

l DETERMINES ORBITAL SHAPES:

$l=0$ S-TYPE S-ORBITAL:



SPHERICAL

$l=1$ p-TYPE p-ORBITALS:

TWO BALLOONS TIED TOGETHER (3 p-ORBITALS x, y, z)

$l=2$ d-TYPE d-ORBITALS

(5 TOTAL)

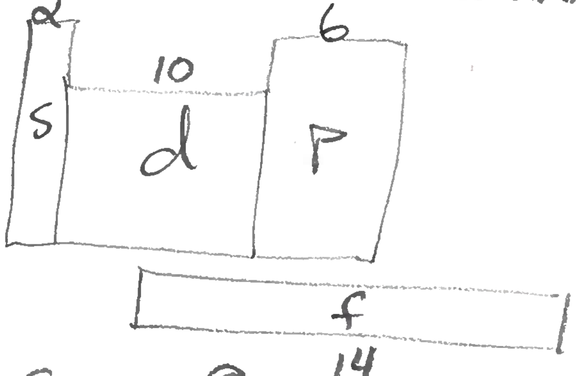
$l=3$ f-TYPE f-ORBITALS (7 f-ORBITALS) GO LOOK UP SHAPES

m_ℓ MAGNETIC QUANTUM NUMBER

POSSIBLE VALUES: $-\ell, \dots, -1, 0, 1, \dots, +\ell$
(DEPENDS ON ℓ)

$\ell = 0$ (s) $m_\ell = 0$ ONE S-ORBITAL
$\ell = 1$ (p) $m_\ell = -1, 0, 1$ THREE p-ORBITALS
(EACH ORBITAL HAS ITS OWN VALUE FOR m_ℓ)
$\ell = 2$ (d) $m_\ell = -2, -1, 0, 1, 2$ FIVE d-ORBITALS
$\ell = 3$ (f) $m_\ell = -3, -2, -1, 0, 1, 2, 3$ 7 f-ORBITALS

EACH ORBITAL IS THE HOME OF UP TO TWO ELECTRONS AND SO THIS GIVES RISE TO THE ORGANIZATION OF THE PERIODIC TABLE:



m_s MAGNETIC SPIN QUANTUM NUMBER

GROUP Y
Tu 2025-11-25
STOPPED HERE AND
DID PHOTOELECTRON
SPECTROSCOPY ACTIVITY

$m_s = +\frac{1}{2}$ OR $-\frac{1}{2}$
UP DOWN (RELATIVE TO AN EXTERNAL MAGNETIC FIELD)
$\uparrow$ $\downarrow$

ANY GIVEN ORBITAL CAN ONLY HAVE 2 e^-s IN IT B/C THE ELECTRONS MUST ALL HAVE DIFF. VALUES FOR ALL FOUR QUANTUM NUMBERS. ONE UP, AND ONE DOWN IS ALL THAT WILL FIT.

STOPPED HERE GROUP X Tu 2025-11-25 HAPPY THANKSGIVING!

Tu 2024-12-03 AP CHEM

FOR $l = 2$ $m_l = -2, -1, 0, 1, 2$ OR 5 VALUES

5 d ORBITALS

~~$l = 3$ $m_l = -3, -2, -1, 0, 1, 2, 3$ OR 7 VALUES~~

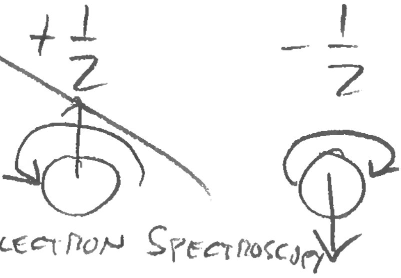
~~7 f ORBITALS~~

REDUNDANT ↗ ↘

~~M_S MAGNETIC SPIN QUANTUM NUMBER~~

~~THE MAGNETIC PROPERTIES OF AN e^- IMPLY THAT THEY SPIN AROUND AN AXIS~~

~~THE SPIN IS QUANTIZED: EITHER "UP" OR "DOWN".~~



STOPPED HERE Tu 2024-12-03 GROUP X AND GROUP Y

DUE TO SNOW DAY ON 12/2... REUSING 2025-12-04 Th NOTES → STILL NEED TO DO PHOTOELECTRON SPECTROSCOPY

EACH e^- IN AN ATOM'S GROUND STATE HAS A UNIQUE SET OF 4 QUANTUM NUMBERS, LIKE AN ADDRESS. (ALSO KNOWN AS THE PAULI EXCLUSION PRINCIPLE).

THE GROUND STATE OF AN ATOM IS WHEN ALL e^-s IN THE ATOM ARE IN THEIR LOWEST POSSIBLE POTENTIAL ENERGIES. AS WE FIGURE OUT HOW e^-s ARE STRUCTURED FOR A GIVEN ELEMENT WE SUPPOSE THAT WE ADD e^-s TO THE STRUCTURE FROM LOW PE TO HIGH PE. THIS IS THE AUFBAU PRINCIPLE.

($2e^-$s PER ORBITAL)

HERE IS THE ORDER:

LOW PE

	n	ℓ	ORBITAL	TOTAL NO. OF POSSIBLE e^-s	
SHELL 1	1	0 = s	1s (ONE)	2 $m_\ell = 0$	$m_s = +\frac{1}{2}$ or $-\frac{1}{2}$
SHELL 2	2	0 = s	2s (ONE)	2 $m_\ell = 0$	8 IN SHELL 2
	2	1 = P	2p (THREE) →	6 B/c $m_\ell = -1, 0, 1$	
SHELL 3	3	0 = s	3s (ONE)	2	8
	3	1 = P	3p (THREE)	6	18
	3	2 = d	3d (FIVE) →	10 B/c $m_\ell = -2, -1, 0, 1, 2$	

ETC. (BUT SEE pg 229 TABLE 6.2)

	n	ℓ	ORBITAL	TOTAL NO. OF POSSIBLE e^-s	
HIGH PE	4	0	4s	2	LOWER IN PE THAN 3d

WHAT DO YOU HAVE TO BE ABLE TO DO?

① BE ABLE TO WRITE THE GROUND STATE ELECTRON CONFIGURATION FOR ANY ELEMENT.

② BE ABLE TO SPECIFY THE FOUR QUANTUM NUMBERS IN ANY ORBITAL.

FOR EX. ....$3d^7$ $n = 3$ $\ell = 2$ $m_\ell = -2, -1, 0, 1, 2$ POSSIBLY OR

....$4s^1$ $n = 4$ $\ell = 0$ $m_\ell = 0$ POSSIBLE

....$4f^{14}$.... $n = 4$ $\ell = 3$ $m_\ell = -3, \ldots, 0, \ldots +3$

FOR ANY e^- $m_s = +\frac{1}{2}$ or $-\frac{1}{2}$

ELECTRON SPIN Th 2024-12-05
+1/2 ↑ -1/2 ↓
AP CHEM

HUND'S RULE

IN A SET OF ORBITALS IN A GIVEN SUB-SHELL $(\cancel{s}, \overset{3}{p}, \overset{5}{d}, \overset{7}{f})$ THE e^-S WILL SPREAD OUT INTO SEPARATE ORBITALS BEFORE THEY PAIR UP IN A SINGLE ORBITAL.

$2p^2$: $\underset{-1}{\uparrow}\ \underset{0}{\uparrow}\ \underset{1}{\_\_}$ (m_l) OR __ ↓ ↓ OR ↑ __ ↑

EQUIVALENT AND LOWER IN PE THAN ↑↓ __ __

LOWEST PE IS WHEN SPINS ARE PARALLEL ↑ ↑ __ OR ↓ ↓ __

NOT ANTI-PARALLEL ↑ ↓ __

ADD e^-S TO A P-SUBSHELL ONE AT A TIME

↑ __ __
↑ ↑ __
↑ ↑ ↑
↑↓ ↑ ↑
↑↓ ↑↓ ↑
↑↓ ↑↓ ↑↓

PAULI EXCLUSION PRINCIPLE

ELECTRONS WITH THE SAME SPIN CANNOT OCCUPY THE SAME ORBITAL.

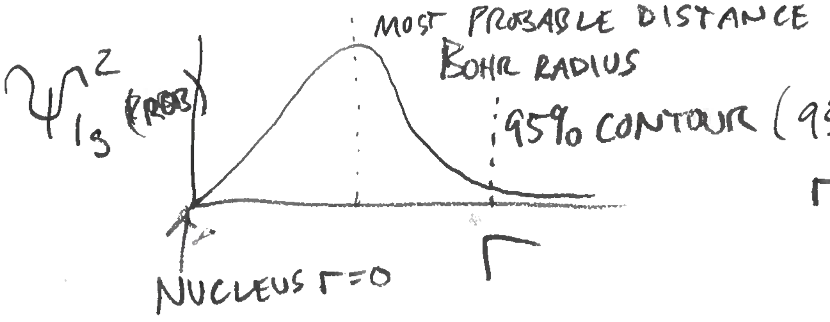
OR, STATED OTHERWISE, NO 2 e^-S IN THE SAME ATOM CAN HAVE ALL FOUR QUANTUM NUMBERS BE THE SAME.

THIS IS WHY ONLY 2 e^-S PER ORBITAL AND WHY THEIR SPINS MUST BE OPPOSITE.

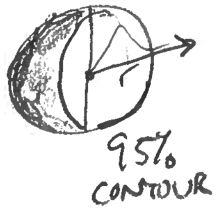
RADIAL PROBABILITY FUNCTION

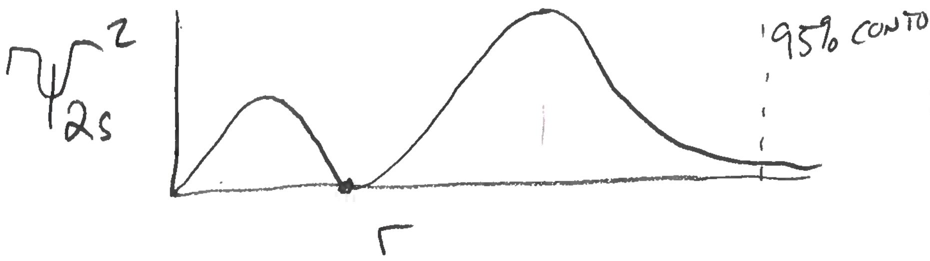
SEE THE ORBITRON ONLINE

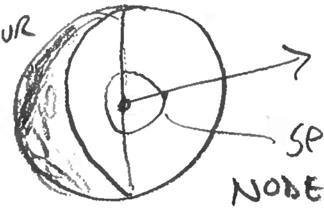
ψ^2 IS THE PROBABILITY THAT AN e^- CAN BE FOUND AT SOME DISTANCE (r) FROM THE NUC.



(95% OF THE TIME e^- IS AT $r <$ THIS VALUE)







SPHERICAL NODE, OR PLACE WHERE NO e^- CAN BE FOUND

A NODE IN A STANDING WAVE IS A POINT OR SURFACE WHERE THERE IS NO MOTION OF THE WAVE MEDIUM. FOR AN e^- THIS WOULD BE ZERO PROB.

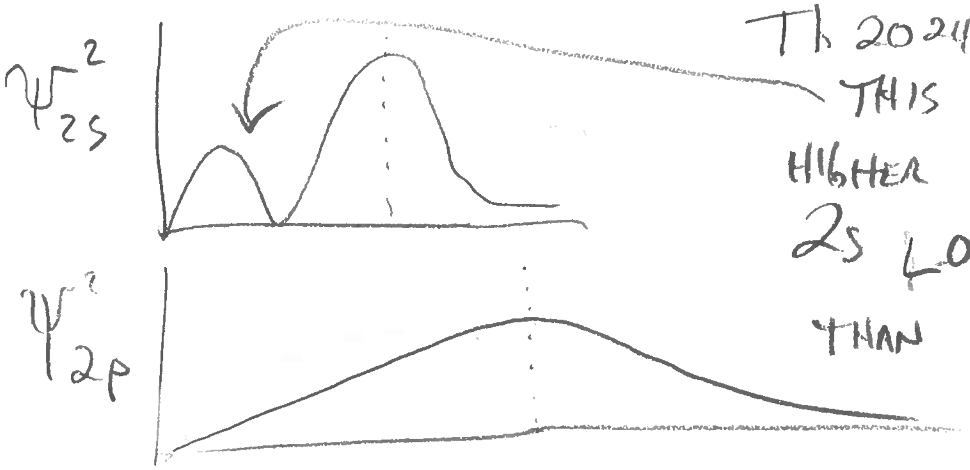
NUMBER OF NODES DEPENDS ON SUB-SHELL TYPE

FOR

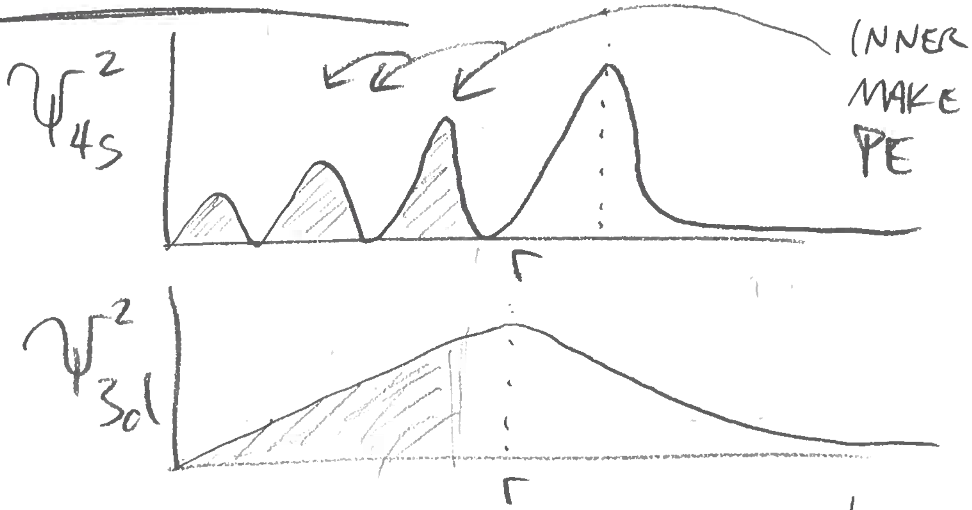
	NO. OF NODES
s	$n-1$
p	$n-2$
d	$n-3$
f	$n-4$

WHY DOES THIS MATTER? IT MATTERS B/C IT EXPLAINS WHY THE $PE_{2s} < PE_{2p}$ AND $PE_{4s} < PE_{3d}$

TH 2024-12-05 AP CHEM



THIS INNER PEAK OF HIGHER PROBABILITY MAKES 2s LOWER IN PE THAN 2p



INNER PEAKS OF PROB. MAKE 4s LOWER IN PE THAN 3d

6.7 MANY-ELECTRON ATOMS

FOR HYDROGEN ALL SUBSHELLS IN A SINGLE SHELL ARE DEGENERATE (HAVE THE SAME ENERGY)

① PE WITHIN A SHELL INCR. AS $s \rightarrow p \rightarrow d \rightarrow f$

② FOR ANY nd SUB-SHELL, THE $(n+1)s$ SUBSHELL IS LOWER IN PE. $PE_{4s} < PE_{3d}$ AND $PE_{5s} < PE_{4d}$ ETC.

③ FOR ANY nf SUB-SHELL, THE $(n+2)s$ SUBSHELL IS LOWER IN PE $PE_{6s} < PE_{4f}$

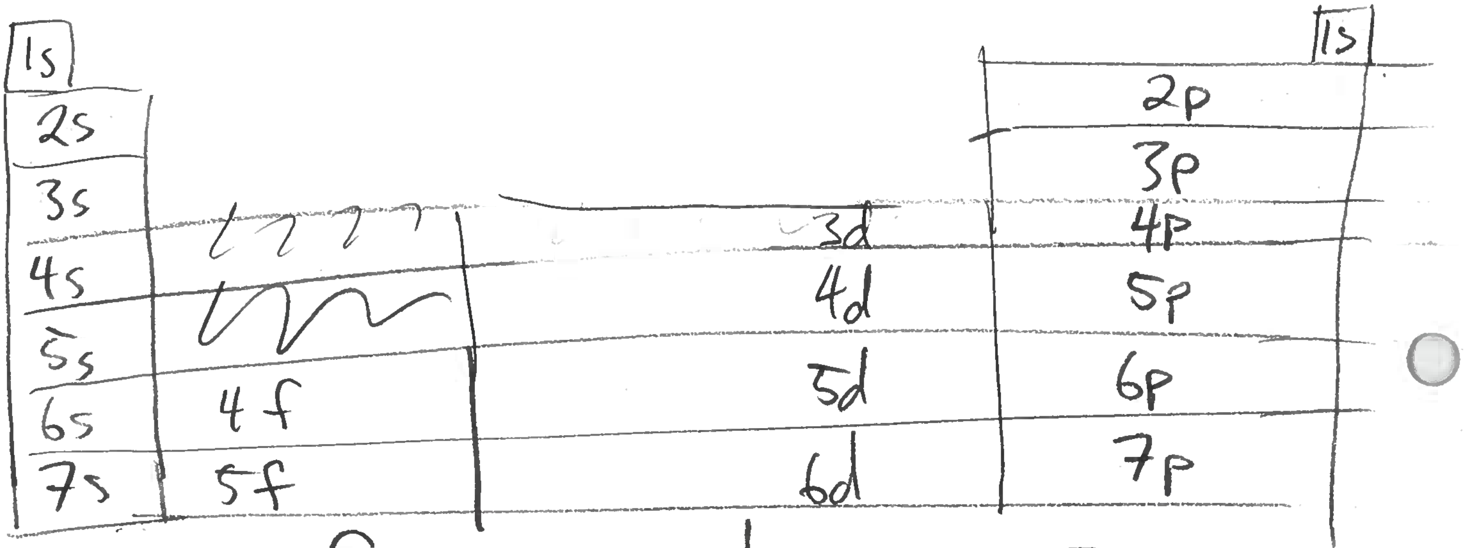
6.8 ELECTRON CONFIGURATION

YOU NEED TO BE ABLE TO WRITE OUT THE GROUND STATE ELECTRON CONFIGURATION FOR ANY ELEMENT.

THE E.C. SPECIFIES THE NUMBER OF ELECTRONS IN EACH SUBSHELL FOR AN ATOM IN ITS LOWEST-ENERGY STATE.

IN ADDITION YOU NEED TO KNOW AT A GLANCE WHAT THE HIGHEST OCCUPIED ORBITAL(S) IS/ARE FOR A GIVEN ELEMENT. THESE ELECTRONS ARE THE VALENCE ELECTRONS AND THEY DETERMINE HOW AN ATOM BEHAVES.

USE THE PERIODIC TABLE AS YOUR GUIDE TO WRITING THE E.C. OF ELEMENTS BY THINKING OF IT IN FOUR BLOCKS.



S-BLOCK	f-BLOCK	d-BLOCK	P-BLOCK
2 WIDE	14 WIDE	10 WIDE	6 WIDE
1 S-ORBITAL PER SHELL	7 f-ORBITALS	5 d-ORBITALS	3 P-ORBITALS

TO FIGURE OUT AN E.C. TRACE YOUR FINGER ACROSS THE ELEMENTS BY INCR. ATOMIC NO. ALL ORBITALS ALONG THE WAY ARE FILLED UP. THE LAST BLOCK, WHERE YOU FIND YOUR ELEMENT MAY BE PARTIALLY FILLED.

FOR EX. $_{3}Li\ 1s^2 2s^1$ ← SUPERSCRIPTS ARE THE NO. OF ELECTRONS

$_{9}F\ 1s^2 2s^2 2p^5$

$_{26}Fe\ 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$ $\underbrace{\uparrow\downarrow\ \uparrow\ \uparrow\ \uparrow\ \uparrow}_{3d}$

Th 2024-12-05

In your book on ~~pp~~ Pg 245 Fig. 6.31 AP Chem
You'll find every electron configuration

Some have exceptions to the filling order you get by following the trace-across method do exist. You are not expected to memorize them.

Some E.C.s are very long (Gold, anyone? 79 e^-s!) so to save time and to emphasize patterns within groups we use condensed E.C.s. These start with a code representing a "noble gas core".

For ex.

$He \quad 1s^2 = [He]$

$Ne \quad 1s^22s^22p^6 = [Ne]$

$Ar \quad 1s^22s^22p^63s^23p^6 = [Ar]$

${}_{36}Kr \quad \ldots \quad [Kr]$

${}_{54}Xe \quad \ldots \quad [Xe]$

Halogens

$$\left.\begin{array}{l} F \ [He]2s^22p^5 \\ Cl \ [Ne]3s^23p^5 \\ Br \ [Ar]3d^{10}4s^24p^5 \end{array}\right\} \text{Valence electron configuration } \boxed{ns^2np^5}$$

Noble gas core electrons do not participate in bonding or forming ions. Only valence electrons are involved in chemical reactions.

$${}_{26}Fe \quad [Ar]\underset{\uparrow}{4s^2}3d^6$$

Still the valence shell

By losing $2e^-$s Fe becomes Fe^{2+}

By losing 1 more e^- Fe^{2+} becomes Fe^{3+}

By valence we usually mean highest value of n.